Environmental Characteristics of the Atmosphere of Residential Agglomerations
I. Dustiness of the Agglomerations*

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The dustiness of residential agglomerations is of complicated character and it is divided into two groups: the gravitation dust sediments, and the airborne dust. For the general environment, the gravitation dust sediments, as the main part of the whole dustiness is more important. On the other hand, the airborne dust is more toxic only for the human population. Generally it is valid that the monthly change of the amount of dust particles is besides the dustiness by emission sources significantly caused by the meteorological situation, namely by the amount of atmospheric precipitations and by the character of dominant winds. The agricultural activities, namely the scattered soil particles influence the regional dustiness laterally.

By comparing the dustiness of the residential agglomerations in Germany with the dustiness of the Košice valley it is possible to say that the German agglomerations are characterized with lower dustiness of factor about 3 to 7. For both agglomeration systems, with the exception of not typical artefactual value, are valid decrease and increase of the amount of gravitation dust sediments in the dry and in the wet atmospheric periods, respectively.

The dustiness of the residential agglomerations is mainly generated by the dustiness of the atmosphere, the urban and industrial anthropogenic activities. The atmospheric dustiness itself consists of two constituents: the gravitation dust sediments, and the airborne dust [1]. The first kind of dusts sediment spontaneously, because their grain size is larger than 10 μm in diameter. These parts of dust contaminate the soils, the urban areas, and the atmospheric rains. Therefore, the chemical character of this dust is determining from the standpoint of general environmental hazards. The second kind of dusts is represented by the grain size smaller than 10 μm, respectively 5 μm. This part of dustiness is a stable atmospheric component, and it is only partially washed out with rains, fog, and snow. Its environmental hazard has a laryngo-pharyngeal character only. This hazard lies in the small particles which have large active surface and adsorb the inorganic and organic solids, liquids, and gaseous pollutants individually [2]. In the given article, the gravitation dust sediments, due to their predominant significance for the toxicity of residential areas and soils [3] are discussed only.

EXPERIMENTAL

Two regions were selected for the sampling. The first group included four cities in the German Federal Republic with remarkably different environmental characteristics. They are the following: Dortmund with typical industrial area, Göttingen with preferred agricultural area, Mainz with vineyard area, and two places in Jülich with combined agricultural and open air mine area.

The second group consisted of four localities surrounding the city Košice (Fig. 1) in East Slovakia. These are: *1.* the hill Bankov 5 km northerly from Košice; *2.* Košice in the centre; *3.* village Šebastovce

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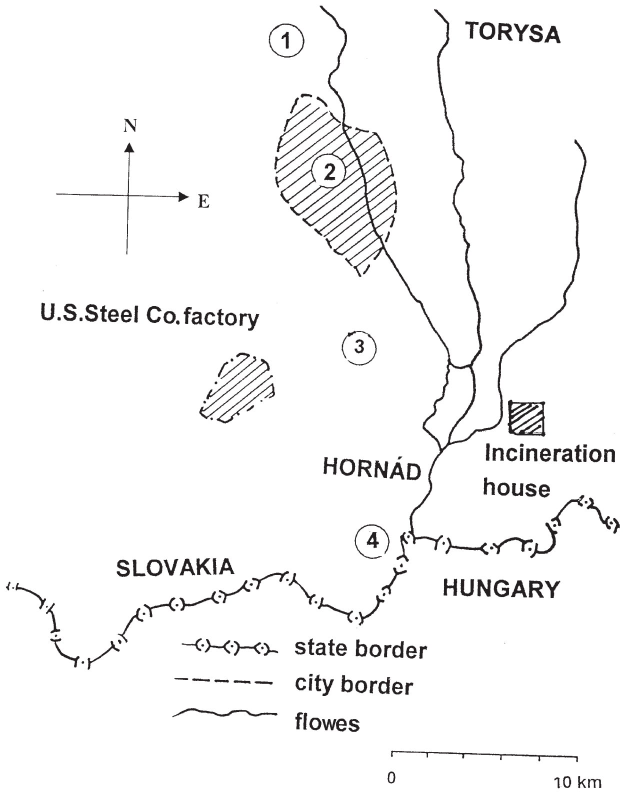

Fig. 1. Gravitation dust sediments sampling localities in East Slovakia. *1.* Bankov, *2.* Košice-centre, *3.* Šebastovce, *4.* Hraničná nad Hornádom.

situated on the N-S axis 6 km to the south of Košice; *4.* village Hraničná, on the N-S axis 18 km to the south of Košice.

The gravitation dust sediments were sampled by the Bergerhoff [4] method. One-month (28 days) sampling period was usually applied. In Germany the first sampling plate was situated in the height of *ca.* 1.5 m above the earth surface, and the second on the top of the meteorological tower of KFA-Jülich. The sampling stations in Slovakia were situated also 1.5 m above the earth surface. In this manner obtained mixtures of rainwater, snow, and the sedimentary solid particles were vacuum-dried to final product with the total weight ranging from 70 to 200 mg of solid product. The inorganic part of this product changed from 55 % to 85 %. The total amount of solid particles is expressed as t km^{-2} y^{-1} or t km^{-2} month^{-1}.

RESULTS AND DISCUSSION

The whole year amount of the gravitation dust sediments $\Sigma m(\mathrm{X})$ and the arithmetic mean value $\overline{m}(\mathrm{X})$ calculated from the whole month sampling products $m(\mathrm{X})_i$ are characteristic values for the given territory (X). Generally it is valid that the monthly change $\Delta m(\mathrm{X})_i$ of the dust sediments is significantly dependent on the meteorological situation, mainly on the amount and duration of atmospheric precipitation products.

$$\Delta m(\mathrm{X})_i = m(\mathrm{X})_i - \overline{m}(\mathrm{X}) \qquad (1)$$

The ascending character of the amount of atmospheric precipitation in the wet periods activates the observed dustiness. On the contrary, the decrease of the atmospheric precipitation in the dry periods activates the decrease of the dustiness. The amount of regional dustiness is influenced also by the intensive agricultural activities (tilling of the soil), and by the dispersion of the soil particles by wind. The final dustiness is then a product of the interaction of both mentioned factors.

First of all it was determined that the value of arithmetical mean $\overline{m}(\mathrm{X})$ corresponds to the value of medians $\tilde{n}(\mathrm{X})$. That fact confirms the symmetrical character of the distribution of individual monthly values $m(\mathrm{X})_i$ around the value of arithmetic mean [5]. That fact justifies the use of the Gaussian statistics for the evaluation of the given analytical data. The determined value of the relative precision $s(m_{\mathrm{X,r}})$ of the determination of monthly dustiness $m(\mathrm{X})_i$ expresses the reproducibility of the dustiness sampling method. In the given case, this value was approximately ± 5 to ± 7 %. That value represents the criterion of the resolving power of this sampling method.

The second crucial problem of the dustiness sampling is the determination of the differentiation of dust amount in dependence on the height of sampling station above the surface area. The given possibility of sampling in the field of KFA-Jülich, Germany was utilized. One sampling station was situated in the 1.5-m height above the surface, and the second one in the height 119 m on the top of a meteorological tower. The sampling was made under identical time conditions at both the stations. The time interval was 28 days during one-year period.

The arithmetical mean $\overline{m}(\mathrm{X})$ was calculated from the monthly values $m(\mathrm{X})_i$, when $i = 1,\ldots,12$. The results are presented in the so-called differential histograms (column diagrams) as function $\Delta m(\mathrm{X})_i = f(\mathrm{time})$. Fig. 2 presents the monthly positive and negative differences from the arithmetical mean value. On the basis of comparison of the change of values $\Delta m(\mathrm{X})_i$ for both sampling stations it is possible, except the one artificial value (A station, the 5th month), to confirm the dustiness affinity on both the sampling stations. This fact confirms that the dustiness in the height of 119 m is similar to the dustiness on the surface. It may be stated that in the dry period (December, January till April) a clear dustiness minimum is observed down to −50 %. On the other hand, in the wet period (July till August, partially November) a clear dustiness maximum is observed. The comparison of the monthly dustiness differences in the residential agglomeration of Mainz and Göttin-

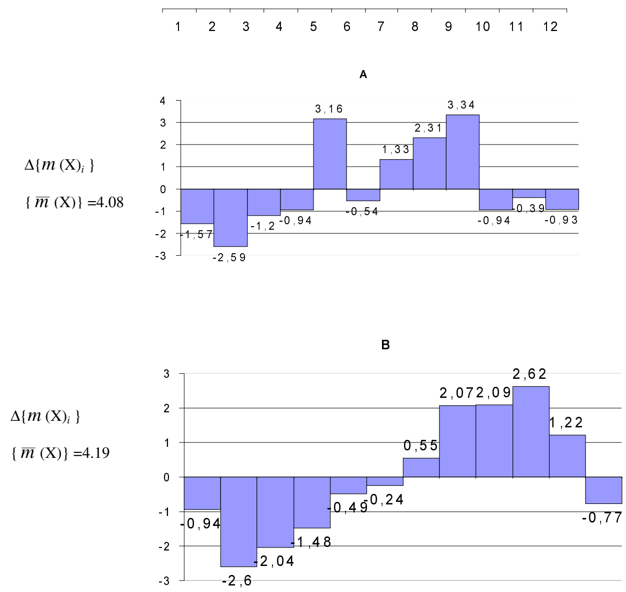

Fig. 2. Differential column diagrams of the changing of gravitation dust sediments. Sampling locality in KFA-Jülich: A. 1.5 m over of the earth surface; B. 119 m high on the top of the meteorological tower. The $\overline{m}(X)$ and $\Delta m(X)_i$ values are in t km^{-2} month^{-1} units.

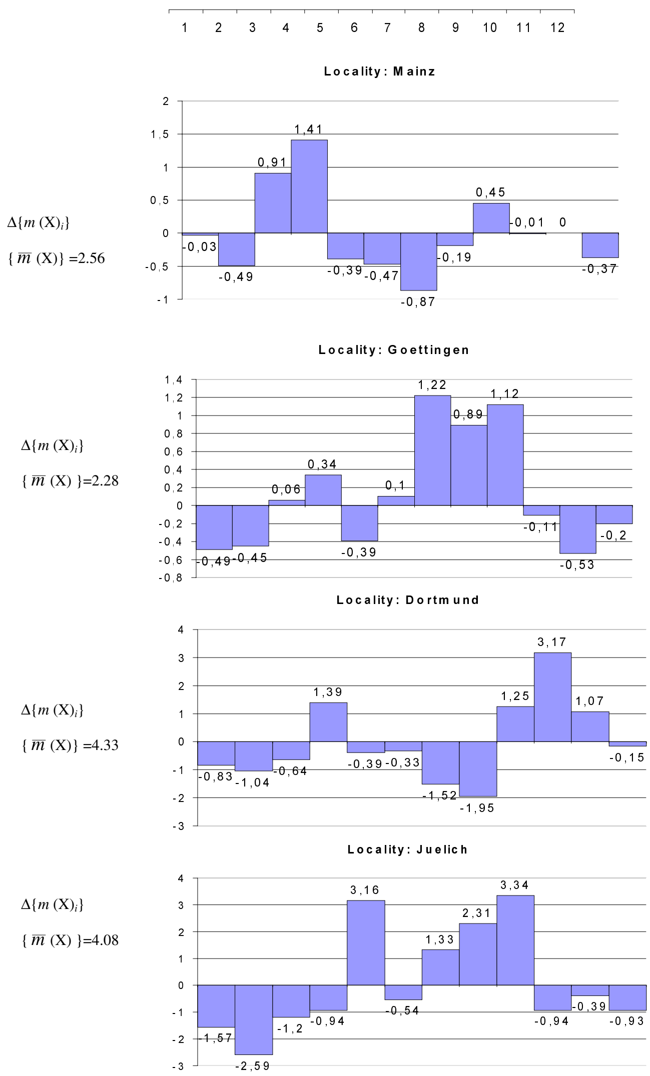

Fig. 3. Differential column diagrams of the changing of gravitation dust sediments. Sampling localities in Germany: Mainz, Göttingen, Dortmund, and Jülich.

gen (Fig. 3) presents only partial similarities. In Mainz in the months March and April, when the agricultural activities in the vineyards reach the maximum intensity, the dustiness is characterized with clear maximum. On the other hand, in the area of Göttingen, where the general agricultural activities, especially the ploughing of the soil, are concentrated to the autumn period, the dustiness achieves its maximum during July and August. The part of the industrial dustiness activity in both the localities is approximately constant. The value of the arithmetical mean $\overline{m}(X)$ for both mentioned localities is in the scope of reproducibility approximately equal.

The arithmetical means of dustiness values of the observing station in Dortmund and Jülich are in the scope of the measuring precision equal, but this value is about twice as high as the values for Mainz and Göttingen. This fact is easily understandable with the location of Dortmund in the centre of metallurgical factories emissions concentration and Jülich in the vicinity of an open-air mine area, and an electric power plant. For both compared stations in the spring period (April to May) the clear dustiness maximum is characteristic. This phenomenon was created by intensive rain activities. On the contrary, the autumn dustiness maxima in Dortmund and Jülich are not corresponding. In the case of Dortmund, the months September to November, and of Jülich the ones July to September are characterized with extreme dustiness maxima.

The meteorological situation (temperature, atmospheric pressure, precipitation deposits) in the Košice valley is approximately uniform. The atmospheric situations are characterized by two types of prevailing wind systems. The dominating wind type is the system of NW, N, and NE streams, and the lateral the SW, S, and SE stream. In the discussed terrain the preferred wind directions followed the direction of the rivers flow (N → S), in this case the direction of the flow of river Hornád. The actual wind roses are in Fig. 4. Consequence of this phenomenon is the asymmetrical distribution of the city dustiness in Košice [5]. For the northern winds the dustiness increases in the northern part of Košice rapidly, reaches the maximum in the middle part of city Košice, and in the southern part of Košice decreases monotonously from the centre to the southern part. For the southern wind system the dustiness increases from the northern part of Košice, attains the maximum beyond the city centre and in the south direction it is approximately constant. This circumstance causes the deposition of the main part of

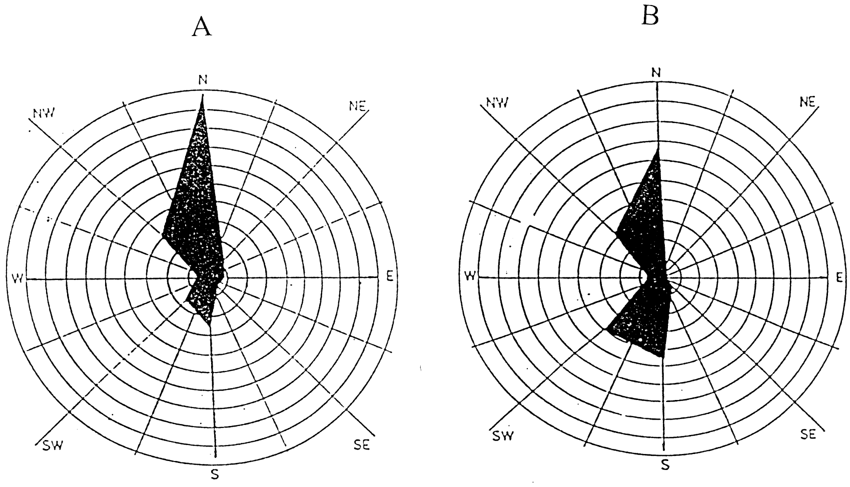

Fig. 4. Wind roses of the typical meteorological situations of the Košice valley. A. System of prevailing northern winds; B. system of prevailing southern winds.

the atmospheric dustiness in the centre of city Košice. For the Košice valley (Fig. 5) it is further characteristic that in the months January to April the northern winds and the expressive atmospheric precipitation as snow, fog, and rainfall prevail. The consequence of these factors, mainly if the wind speed gradually decreases, is the increasing dustiness and therefore increase of the value $\Delta m(\mathrm{X})_i$. In May to July, the equivalence between the prevailing northern and southern winds exists. The rains in these months are coming from the cumulus form clouds (whole-pack cloud) and therefore this rainfall has only local and limited character and influence on the dustiness. The amount of dustiness in this period changed therefore very anomalously. In the months August, September and mainly in October southern winds prevail in the Košice valley and this time period is characteristic by the dry atmospheric situation. In this period clear decrease of the dustiness below the limit of arithmetical mean $\overline{m}(\mathrm{X})$ is observed. In the months November and December the atmospheric precipitations increase, they "wash out" the atmospherical dustiness and the amount of observed gravitation dust sediment increases above the limit of the arithmetical mean value of dustiness.

The sampling in the locality Košice-centre was repeated in the two-year period. From Fig. 6 the similarity of both courses is evident. Only in the two-year period in the months June and November an artificial phenomenon was observed which was caused probably by the higher rainfall. Both courses confirmed the constant distribution character of the dust fall in the Košice-centre. Also the course of the $\Delta m(\mathrm{X})_i$ value is typical for the given localities. Very similar result was obtained for the other localities.

In conclusion it is possible to state that the Bergerhoff sampling method gives the relative precision value between ± 5 to ± 8 %. This value is the criterion for the distinguishing between the dustiness values. The monthly change of the amount of gravitation dust sed-

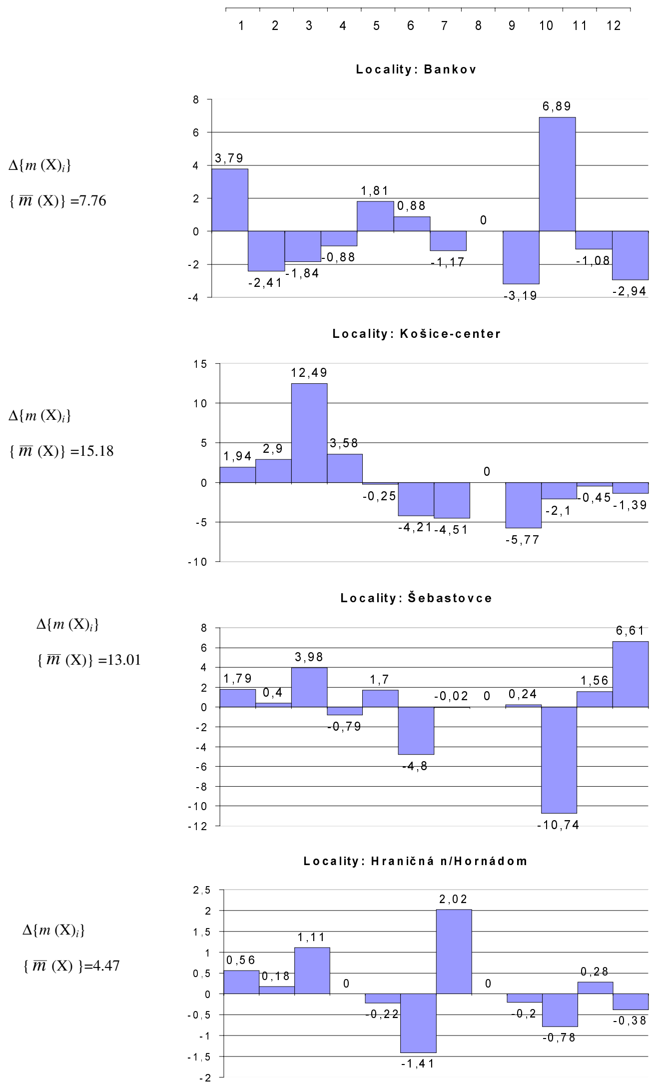

Fig. 5. Differential column diagrams of the changing of gravitation dust sediments. Sampling localities along the N-S axis in the Košice valley: *1.* Bankov, *2.* Košice-centre, *3.* Šebastovce, *4.* Hraničná nad Hornádom.

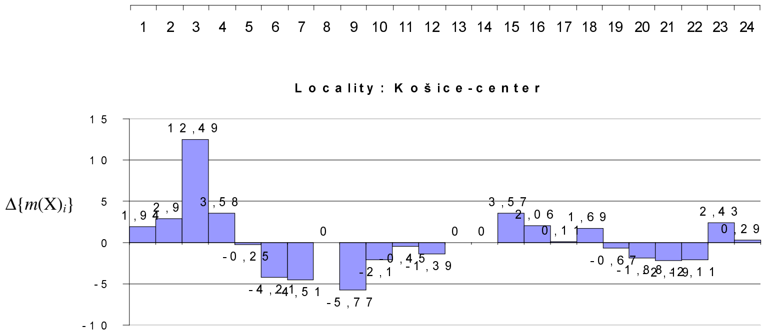

Fig. 6. Differential column diagrams of the changing of gravitation dust sediments for two-year sampling period in the locality Košice-centre.

iment is dependent on the amount of atmospheric precipitations and partially of prevailing winds. Gradual decrease of the wind speed causes increasing of both: the sedimentation processes and the amount of gravitation dust sediments.

Observing the dustiness in the north-south direction of the Košice valley it is possible to say that this dustiness has a maximum course, and in the south end of the valley a minimum one. Expressive is the similarity of the dustiness of Mainz and the Košice-centre. But remarkably different is the dustiness of Dortmund and partially Jülich including their industrial background, from the Košice valley. Remarkable is also the difference between the dustiness of Mainz and Göttingen on the one hand, and Dortmund and Jülich on the other. This difference is higher by the factor 2.

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